

gills atrophy later. During the process of their doing so, the *Lepidosiren* passes through a condition in which the stumps persist evidently corresponding to that well known in the young *Protopterus*, the group of external gills with their common stalk having come by differential development to be situated immediately above the fore limb. After the close of the larval period the *Lepidosirens* become much darker in colour and more lively in their movements. Young were obtained from the nest up to a length of 60 mm. About this time the cornea begins to assume the white unhealthy appearance that it has in the adult. In the young of this size, small yellow spots appear, and in the young of 90 mm. these are conspicuous. Occasional yellow blotches persist in the young *Lepidosiren* of eighteen months, but in the adult they disappear.

The paper concludes with general remarks on the phenomena described. The segmentation approaches most closely that of *Ganoids*. The shortening up of the invaginating groove is considered to illustrate a process which has taken place in phylogeny in the passage from the primitive holoblastic egg to the meroblastic condition. The continuity of the medullary folds behind the anus is adduced, together with the evidence accumulating of the prolongation of the blastopore along the floor of the medullary groove in other forms (*Amphibia*, *Ceratodus*, *e.g.*) as affording potent evidence in favour of the hypothesis which derives the *Vertebrata* from ancestral forms as primitive as the *Cœlenterata*, and possessing a nelongated mouth traversing the neural surface. The occurrence of external gills in the young of three so comparatively primitive groups of *Vertebrata* as *Crossopterygians*, *Dipnoans*, and *Amphibians*; their occurrence on four branchial arches in *Lepidosiren*, and on at least the hyoid arch in *Crossopterygians*, and the occurrence of a probable homologue on the mandibular arch in *Urodela*, are taken as suggesting that these structures are organs of great antiquity in the *Vertebrate* stem, and that there was formerly one present on each visceral arch. It is pointed out that were this so, it would afford a theory of the origin of the vertebrate limb, which would be supported by much of the evidence brought forward by the supporters of the Gegenbaur view, and which at the same time would avoid the most important difficulties in the way of this view.

“The Thermal Expansion of Pure Nickel and Cobalt.” By A. E. TUTTON, B.Sc. Communicated by Professor TILDEN, D.Sc., F.R.S. Received April 18,—Read May 4, 1899.

(Abstract.)

The author has carried out a series of re-determinations of the coefficients of thermal expansion of these two metals with the aid of the interference dilatometer described in a former communication to the

Society.* Since the determinations made by Fizeau in the year 1869, a large amount of additional knowledge has been accumulated with reference to nickel and cobalt, including the discovery of the liquid nickel carbonyl, which places processes of purification in the hands of the chemist of a character so superior to the older methods, as to render it highly desirable that re-determinations of the physical constants of these interesting elements should be carried out with specimens of the metals thus purified. By the kindness of Professor Tilden, who has prepared such specimens with infinite care for the purposes of the investigation of other physical and chemical characters, the author has been enabled to carry out determinations of the thermal expansion with rectangular blocks varying in thickness from 8 to 13 mm. The blocks were furnished with parallel and truly plane surfaces by the makers of the dilatometer, Messrs. Troughton and Simms. The range of temperature of the observations was from 6° to 121°.

The results of the determinations of the coefficients of linear expansion α are as follows:—

$$\alpha = a + 2bt.$$

For nickel.....	$\alpha = 0.000\ 012\ 48 + 0.000\ 000\ 014\ 8t.$
For cobalt.....	$\alpha = 0.000\ 012\ 08 + 0.000\ 000\ 012\ 8t.$

Nine different determinations were carried out for each metal, three in each of the three rectangular directions, in order to eliminate any slight error due to directional strain in the metallic blocks. As the metals crystallise in the regular system, the expansion should be the same in all directions. The metal in each case had solidified after fusion in an oxy-hydrogen flame in presence at the last of excess of oxygen. The individual results are highly concordant, the highest result for cobalt being still lower than the lowest of the nine values obtained for nickel. Hence there can be no doubt that the above coefficients represent the true relationships.

The main result of the investigation may be summarised as follows:—The coefficients of linear expansion α of pure nickel and cobalt exhibit a slight but real difference, the coefficient of nickel being distinctly greater than that of cobalt. This is true with respect to both the constant a , the coefficient for 0°, and the increment per degree, $2b$, of the general expression for the coefficient at any temperature t , $\alpha = a + 2bt$. The difference is consequently one which augments with the temperature; at 0° it amounts to 3.2 per cent., while at 120°, the upper limit of the temperatures of the observations, it attains 4.5 per cent. Similar rules apply naturally to the cubical coefficients. The metal possessing the slightly lower atomic weight, nickel, is thus found to expand to a greater extent than the metal, cobalt, which is endowed with the higher atomic weight.

* 'Phil. Trans.,' A, vol. 191, p. 313; 'Roy. Soc. Proc.,' vol. 63, p. 208.